PRELIMINARY ENGINEERING DESIGN PACKAGE
FOR
THE BASIN A NECK GROUNDWATER INTERCEPT AND
TREATMENT SYSTEM INTERIM RESPONSE ACTION

FEBRUARY 1989

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Prepared for
Shell Oil Company

02/01/89

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THE INTERIM RESPONSE ACTION FOR THE BASIN A NECK AREA WILL CONSIST OF:

1. SEVEN DEWATERING WELLS
2. SOIL BENTONITE SLURRY WALL 820 FEET IN LENGTH
3. GROUND WATER TREATMENT BY ACTIVATED CARBON ADSORPTION
4. 540 FEET OF GRAVEL FILLED RECHARGE TRENCHES.

THE ENGINEERING DESIGN PACKAGE DISCUSSES EACH OF THE ABOVE ELEMENTS AS WELL AS PROVIDING COST ESTIMATES.

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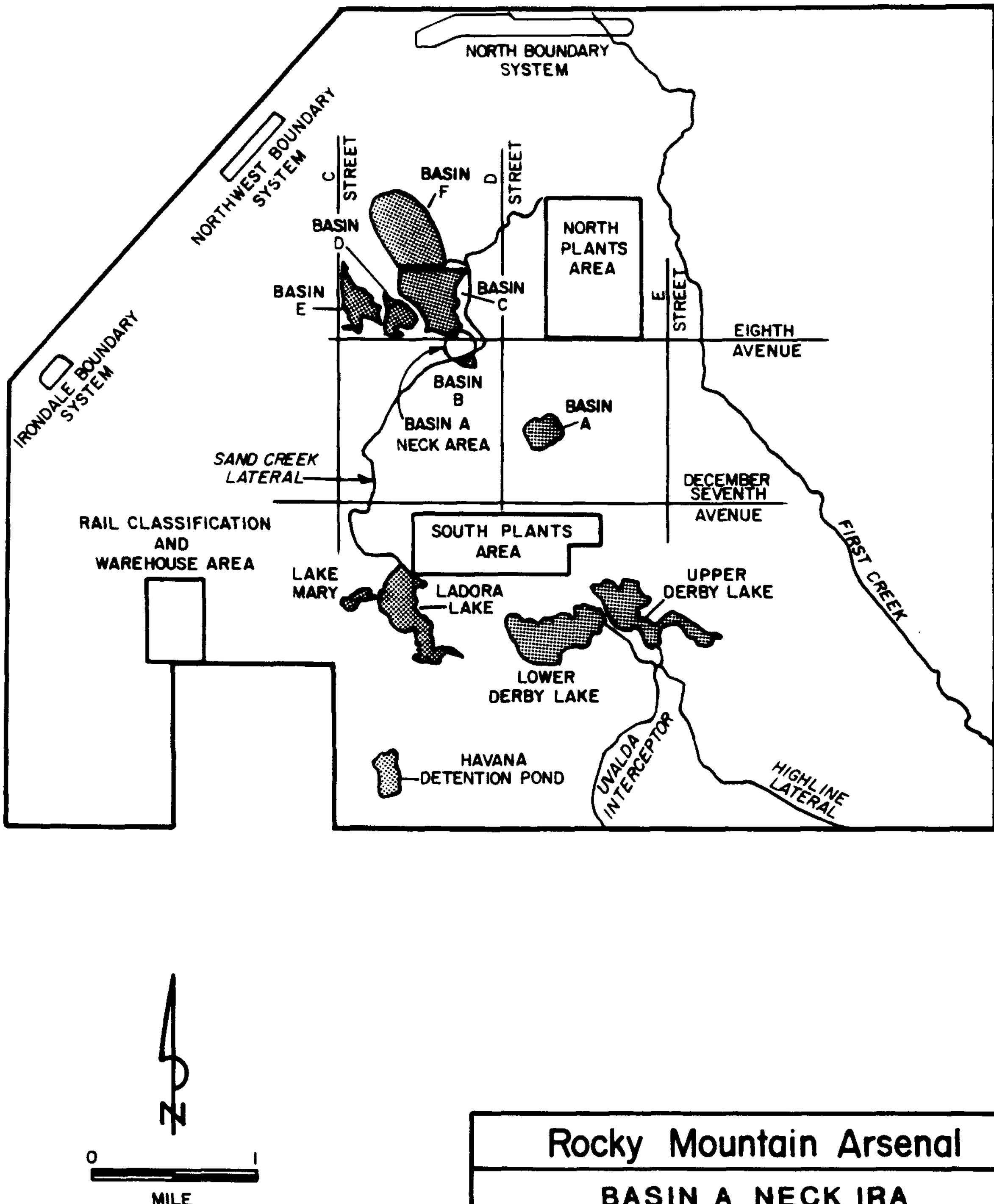
1.0 INTRODUCTION

The Interim Response Action (IRA) for the Basin A Neck Groundwater Intercept and Treatment System at Rocky Mountain Arsenal (RMA) is being conducted as part of the IRA Process for the RMA in accordance with the June 5, 1987 report to the court in United States vs. Shell Oil and the proposed Consent Decree.

This IRA project consists of design and construction of an alluvial groundwater intercept and treatment system in the Basin A Neck area on the RMA (see Figure 1). The purpose of this document is to outline the main elements developed in the Preliminary Engineering phase of the IRA. Although not specifically required by the IRA Process, it is deemed beneficial to circulate this document so that the Parties and State may provide any comments that could affect the final IRA design.



Rocky Mountain Arsenal

BASIN A NECK IRA

Figure 1.

Location Map

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2.0 OVERVIEW OF SYSTEM

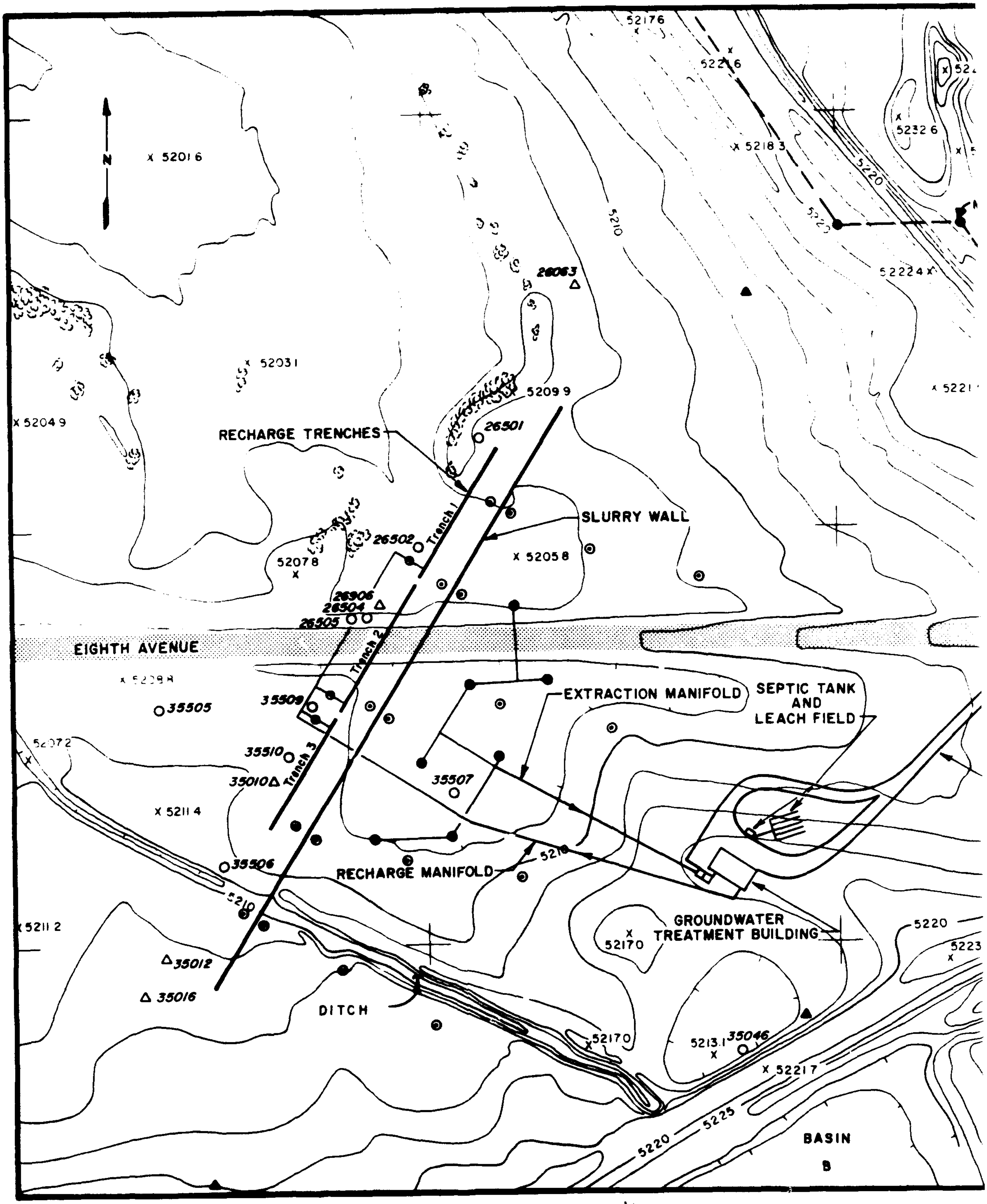
As outlined in the Final Decision Document for this IRA, the Basin A Neck IRA will be composed of alluvial groundwater extraction, groundwater treatment, and recharge systems in the so-called narrow Basin A Neck area as shown in Figure 2. A soil-bentonite slurry wall will also be included as part of the intercept system.

The proposed extraction system is composed of seven alluvial wells located in the deeper and more permeable alluvial deposits near the center of the alluvial channel. The construction of alluvial piezometers in the vicinity of the extraction wells, screened and gravel-packed across the entire alluvial aquifer, will aid in providing connections between any layered permeable zones, thus aiding the dewatering effort. The extraction wells and alluvial piezometers are discussed more fully in sections 3.3 and 3.5, respectively.

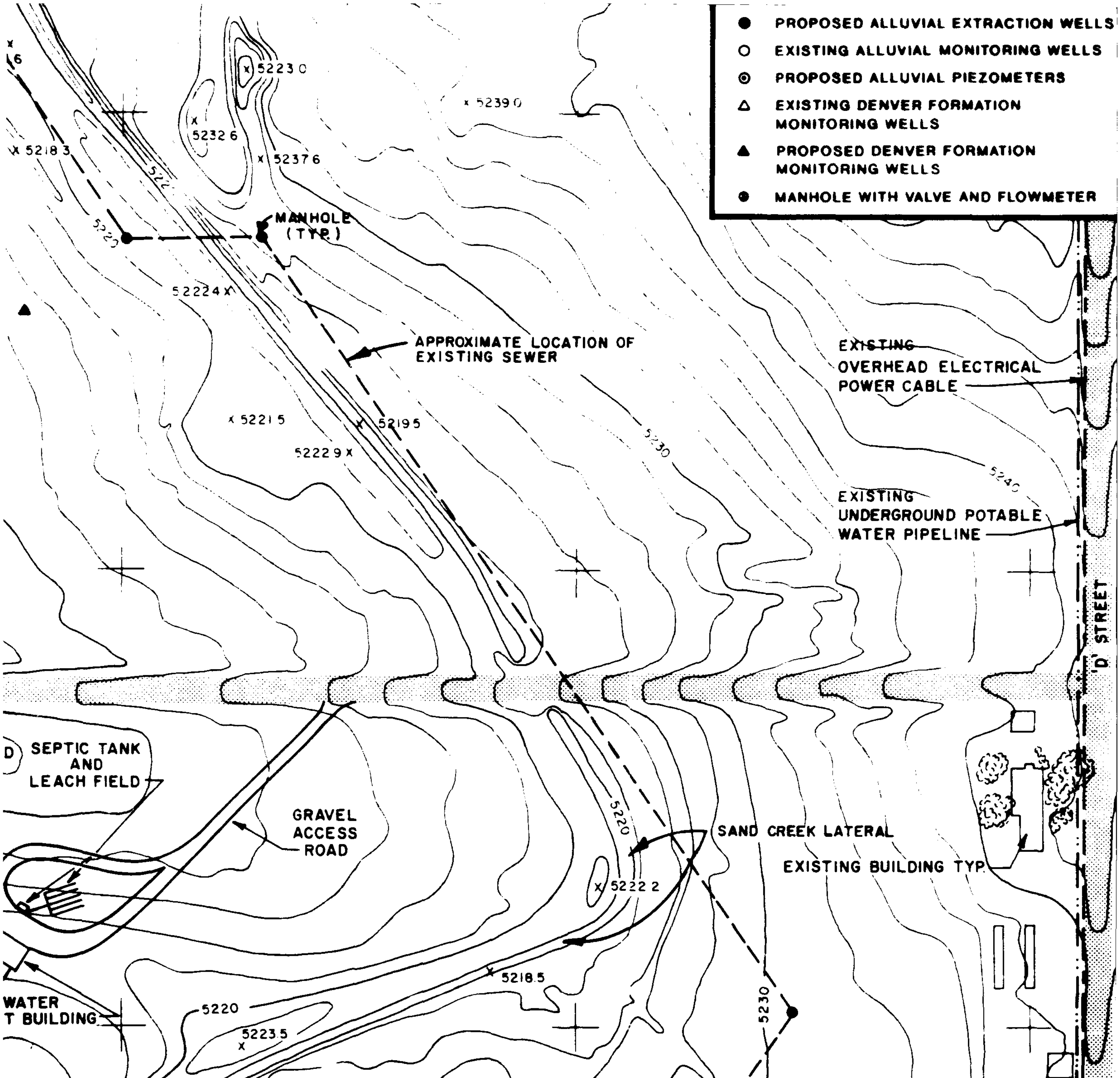
Groundwater treatment will be achieved with the use of activated carbon adsorption for the removal of organic groundwater contaminants. The selected process affords a great deal of flexibility in treating a range of flows containing complex mixtures of organic compounds. The groundwater treatment system is discussed in Section 3.6.

The recharge system will be composed of approximately 540 feet of gravel-filled trenches constructed across the more permeable, deeper portions of the alluvial neck. The recharge system is discussed in Section 3.4.

A soil-bentonite slurry wall, approximately 820 feet in length, will be constructed across the alluvial neck between the recharge trench and extraction wells to limit the amount of recirculation that would otherwise occur between the systems. The slurry wall is discussed in Section 3.2.



N
RECHARGE TRENCHES
SLURRY WALL
EIGHTH AVENUE
EXTRACTION MANIFOLD
SEPTIC TANK AND LEACH FIELD
RECHARGE MANIFOLD
GROUNDWATER TREATMENT BUILDING
DITCH
BASIN
Trench 1
Trench 2
Trench 3
26063
26501
26502
26906
26504
26505
35505
35509
35510
35010
35507
35506
35012
35016
35046
5210
5220
5225



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BASIN A NECK IRA

Figure 2

Site Plan

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3.0 CONCEPTUAL INTERCEPT SYSTEM DESIGN FOR THE BASIN A NECK

3.1 DESIGN FLOW RATE

The design flow rate for the Basin A Neck Intercept System IRA is derived from an estimate of the flow through the alluvial aquifer, plus allowances for potential error in the estimate, recirculation between the recharge and extraction systems, and system downtime.

The flow estimate through the Basin A Neck is based on four aquifer tests. These tests include two long-term injection tests conducted near the center of the A Neck channel in the relatively permeable sediments, one slug test conducted on the southern flank of the neck, and one slug test conducted on the northern flank. The long-term injection tests were conducted by injecting a steady stream of potable water into the respective wells. Theis time-drawdown (or mounding in this case) analyses were performed using the water level data obtained from nearby observation wells. In order to validate the long-term injection test, the procedure was first used in a well in which a pumping test was previously conducted. This well is located upstream of the Neck near Basin A in fairly similar geologic materials. The estimated hydraulic conductivity from the pumping test agreed very well with the estimates produced from the injection test. The long-term injection tests conducted in the Basin A Neck resulted in transmissivity estimates of 4950 gallons per day per foot (gpd/ft) and 6400 gpd/ft for the tests performed in wells 35509 and 26503, respectively. The slug tests were analyzed using procedures outlined by Lohman (Lohman, S.W., 1979, Groundwater Hydraulics, in U.S. Geological Survey Professional Paper 708, pp. 27-29) and produced transmissivity estimates of 2.8 gpd/ft and 362 gpd/ft for the tests conducted in wells 35506 and 26501, respectively. Data from all four of the aquifer tests fit the appropriate type curves very well. The locations of wells 26501, 35506, and 35509, are shown on Figures 2 and 3.

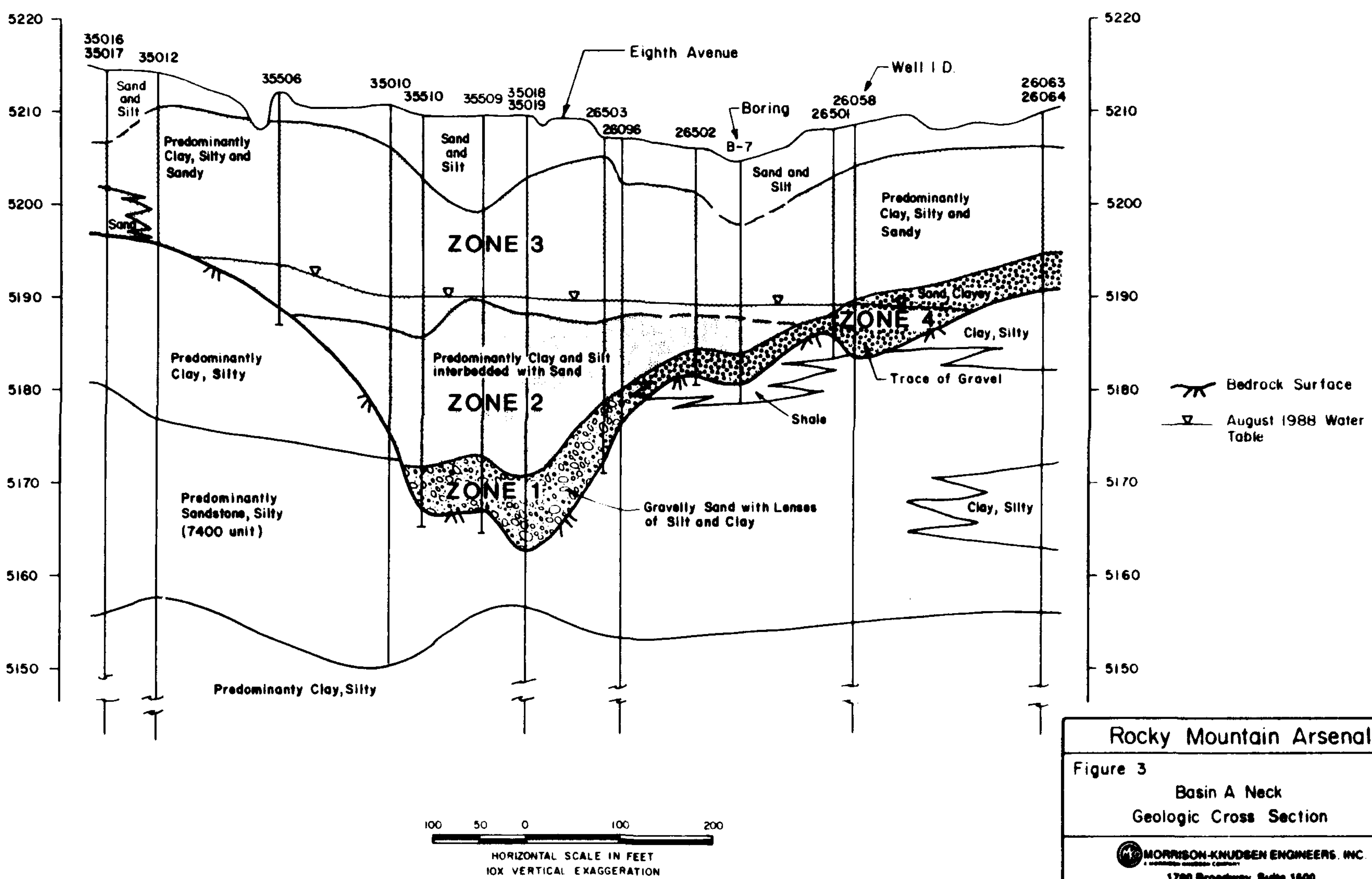

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Figure 3
Basin A Neck
Geologic Cross Section

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Well 26503 (also shown on Figure 3) is located 10 feet east of Well 26504 (shown on Figure 2).

As shown on Figure 3, the aquifer within the Basin A Neck is divided into four lithologic zones. The slug tests produce hydraulic conductivity estimates of zones 3 and 4 of 3.0×10^{-5} centimeters per second (cm/sec) and 8.5×10^{-3} cm/sec, respectively. Estimates of the relative hydraulic conductivity of zones 1 and 2 (based on visual inspection of aquifer samples obtained during drilling) are used in conjunction with the two injection tests in these zones to produce hydraulic conductivity estimates of 3.75×10^{-2} cm/sec and 3.53×10^{-3} cm/sec for zones 1 and 2, respectively. A hydraulic gradient of 0.0115 feet per foot was measured during August of 1988 in the local vicinity of the proposed system. Using the hydraulic conductivities and hydraulic gradient mentioned above, and based on the cross-sectional areas of saturated aquifer shown on Figure 1, flow estimates of 9.43 gallons per minute (gpm), 2.84 gpm, 0.01 gpm, and 1.60 gpm are obtained for zones 1, 2, 3, and 4, respectively. The total estimated flow through the Basin A Neck is 14 gpm.

For an estimate of typical flows expected at the proposed Basin A Neck treatment plant, the estimated 14 gpm of flow through the area is raised by 10 percent to account for some system downtime, resulting in just over 15 gpm. The expected flow is increased to 18 gpm to include an allowance for some limited recirculation either through the slurry wall or beneath the wall in the Denver Formation. The actual amount of recirculation can only be estimated, but construction of a competent slurry wall into any soft portions of the Denver Formation sands should restrict recirculation to a small flow.

For an estimate of the highest treatment flow rate that could reasonably be required of the treatment plant, it is assumed that the aquifer tests underestimated the aquifer transmissivities by 100 percent and 30 percent for the slug tests and long-term injection tests, respectively. Based on this assumption, the estimated alluvial flow through the A Neck is about 21 gpm. After adding 10 percent to allow for some system downtime, and adding a conservative estimate of recirculation through or beneath the slurry wall of about 7 gpm, the resulting estimate of the highest reasonable flow that the treatment plant may need to treat is 30 gpm. Since there will be no recirculation until a reverse hydraulic gradient is developed, the 7 gpm allowance for recirculation will be available for initially overpumping the aquifer to create the desired drawdown upgradient of the slurry wall.

3.2 SLURRY WALL

A soil-bentonite slurry wall will be constructed between the recharge and extraction systems. Scoping calculations on the costs of slurry wall versus treatment system size indicate that a slurry wall is justified on cost savings for the range of flowrates involved with this system. Moreover, as discussed in the Decision Document, the slurry wall provides a degree of safety in the event of temporary shutdown of the extraction system (e.g. electrical power outage, etc.). The slurry wall will be constructed after the extraction, recharge, and treatment systems are operable so that the system can be turned on immediately after construction of the barrier. Otherwise, groundwater blockage caused by the slurry wall would result in a rising water table that could potentially contaminate soils not previously contaminated.

The proposed slurry wall will be located in the area shown on Figure 2, and will extend entirely across the saturated alluvial aquifer in the Neck area. The depth of the slurry wall will be governed by bedrock conditions. At a minimum, it will be keyed at least two feet into the bedrock. Where the bedrock surface is composed of sands, the wall will be extended through any soft portion of the sands, or to a depth of 40 feet from the working bench, whichever is least. This penetration through any soft sands will help minimize recirculation between the recharge and extraction systems. Even if soft sands exist below a depth of 40 feet from the working bench, recirculation beneath a slurry wall constructed to that depth should be minimal.

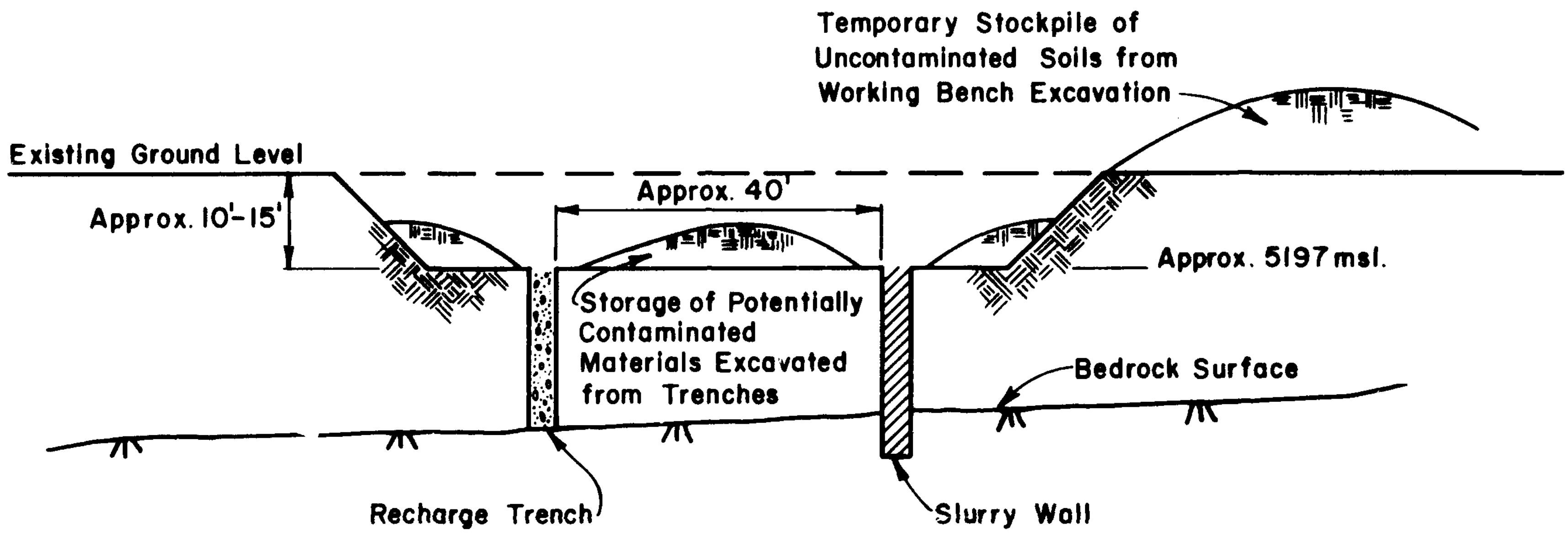
Excavation for slurry wall construction (and also the recharge trench discussed later) will be performed in accordance with the procedures referenced in the Final Decision Document for the Basin A Neck Intercept and Treatment System Intercept System. A working bench concept similar to that used during the recent construction of the North Boundary System recharge trenches will allow any potentially contaminated soils or water encountered during slurry wall construction to be left within the working bench. A cross-section showing the working bench concept is shown in Figure 4.

3.3 EXTRACTION SYSTEM

The extraction system for this IRA will be composed of seven alluvial wells equipped with submersible pumps. The locations of these wells are shown on Figure 2. If performance evaluations of the extraction system demonstrates the need, additional extraction wells can be readily added later. The pumps will be operated by automatic controls based on water levels within the wells and the influent sump at the treatment plant. The water levels at which the pumps start and stop will be adjustable from the treatment plant. Manual pump override capability will be provided both within the treatment plant and at the well. The flow from each well will be metered. The flow readouts will be located within the water treatment plant.

3.4 RECHARGE SYSTEM

Recharge trenches will be utilized to return treated water to the aquifer downstream of the slurry wall. The large contact area between recharge trenches and the adjacent aquifer will help minimize the effects of any plugging caused by suspended



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BASIN A NECK IRA

Figure 4

Cross-section
Showing Working Bench
Construction Concept

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solids, entrained or dissolved air, or other mechanisms. The location of the recharge trenches is shown on Figure 2. They stretch a total of 540 feet across the more permeable and deeper sections of the Basin A Neck channel. The trenches will be constructed from the same working bench described in Section 3.2 and shown in Figure 4 for the slurry wall. The recharge trenches will be constructed from the working surface down to the approximate bedrock surface. The recharge trenches will have a separation between them. At least three vertical perforated or slotted casings, accessible from the ground surface, will be installed within each trench to maximize the ease with which flow can migrate vertically within a trench. In addition two 4-inch piezometers will be installed within each trench. These vertical casings will be connected to two horizontal perforated drain pipes extending the entire length of each trench segment. One of these horizontal pipes will be located near the trench bottom and the other will be located near the trench top. Flow into each segment will be metered. Flow readouts will be located within the water treatment plant.

3.5 MONITORING WELLS

Several alluvial and Denver Formation monitoring wells and piezometers will be installed to complement existing wells, and to allow meaningful assessments of the performance of the Basin A Neck Groundwater Intercept and Treatment System. Since the proposed extraction wells (see Section 3.4) can be used to obtain alluvial water quality data on the upgradient side of the intercept system, most of the additional upgradient monitoring can be accomplished with piezometers. Proposed locations of alluvial and Denver Formation monitoring wells and piezometer locations, as well as locations of existing wells that will be retained and included within the monitoring system, are shown on Figure 2. Denver Formation wells will be constructed to prevent hydraulic connection with the alluvial aquifer.

3.6 GROUNDWATER TREATMENT SYSTEM

3.6.1 Treated Groundwater IRA Standards

In Section 8.3.1 of the Final Decision Document, the Army selects and sets forth the following Groundwater IRA Standards for CERCLA hazardous substances and DIMP which the Army fully anticipates will be achieved at the point of reinjection of the treated groundwater by existing "off the shelf" technology selected for remediation of Basin A-Neck groundwater.

Compound	Groundwater IRA Standard (ug/L)
Benzene	5
Carbon Tetrachloride	5
Chlorobenzene	488
Chloroform	100
DDT	10
1,2-Dichloroethane	5
1,1-Dichloroethylene	7
Dieldrin	0.12
Endrin	0.2
Hexachlorocyclopentadiene	206
Mercury	2
1,1,1-Trichloroethane	200
Trichloroethylene	5
DIMP	9,730

As discussed later in this report (Section 3.6.4.2), these standards will be met by the treatment system selected for this design based on adsorber performance predicted on the basis of compound properties and, in addition, will provide a very significant margin of safety in the event that actual influent water quality is worse than expected and/or actual adsorber performance deviates from that predicted.

Section 8.3.1 of the Final Decision Document also sets forth the following Groundwater IRA Standards for compounds which may require additional treatment in the future, which may be implemented by improvements to this system or within the context of the Final Response Action, or both:

Compound	Groundwater IRA Standard (ug/L)
Chromium	50
Fluoride	4,000
Nitrate	10,000
Arsenic	50

3.6.2 Influent Water Quality

On August 31, 1988, a sampling program was undertaken by Morrison-Knudsen Engineers (MKE) to characterize for design purposes the groundwater quality in the Basin A Neck alluvial channel. Six wells were sampled and are identified by the following Army Well I.D. numbers:

35506	26501	35509
26502	35510	26503

Each well was sampled and analyzed for the suite of organic compounds, inorganic elements/compounds, and water quality parameters listed in Table 1. All organic and some inorganic analyses were performed using USATHAMA certified methods. EPA analytical methods were used for analysis of all other inorganic analytes and water quality parameter. The results of the analyses are presented in Table 1. Also presented in Table 1 are the average concentration and USATHAMA certified reporting limit (CRL) or EPA Analytical Method Detection Limit (MDL) for each analyte.

The average values reported constitute the mean of the concentrations which are above the CRL or MDL for the particular analyte (hits). Of the six wells sampled, three (35509, 35510 and 26503) are characterized by significantly higher groundwater yield and should therefore be most representative of the quality of the water flowing through the Basin A Neck alluvial channel. The average and range of the values from the three wells are presented in Table 2. These average values reported constitute the mean of the hits for the particular compound.

BASIN A-NECK IRA
TABLE 1 - MKE SAMPLING PROGRAM
RESULTS OF GROUNDWATER ANALYSIS

ANALYTE	WELL NO. 35506	WELL NO. 35509	WELL NO. 35510	WELL NO. 26501	WELL NO. 26502	WELL NO. 26503	AVERAGE (NOTE 1)	CRL (NOTE 2)	MDL (NOTE3)
ORGANIC COMPOUNDS									
(VOLATILE) (ug/l)									
BENZENE	LT 2.2	5.80	LT 2.2	LT 2.2	LT 2.2	4.90	5.35	2.20	
CARBON TETRACHLORIDE	LT 2.8	LT 2.8	LT 2.8	LT 2.8	LT 2.8	LT 2.8	LT 2.8	2.80	
CHLOROBENZENE	LT 1.3	LT 1.3	LT 1.3	LT 1.3	LT 1.3	LT 1.3	LT 1.3	1.30	
CHLOROFORM	LT 2.1	LT 2.1	LT 2.1	31.00	LT 2.1	LT 2.1	31.00	2.10	
DICYCLOPENTADIENE	LT 2.1	LT 2.1	LT 2.1	LT 2.1	LT 2.1	LT 2.1	LT 2.1	2.10	
DIMETHYL DISULFIDE	LT 4.6	LT 4.6	LT 4.6	LT 4.6	LT 4.6	LT 4.6	LT 4.6	4.60	
METHYLISOBUTYL KEYTONE	LT 5.6	LT 5.6	LT 5.6	LT 5.6	LT 5.6	LT 5.6	LT 5.6	5.60	
TETRACHLOROETHYLENE	LT 1.3	LT 1.3	LT 1.3	LT 1.3	LT 1.3	LT 1.3	LT 1.3	1.30	
TOLUENE	LT 2.1	LT 2.1	LT 2.1	LT 2.1	LT 2.1	LT 2.1	LT 2.1	2.10	
TRICHLOROETHYLENE	LT 2.4	LT 2.4	LT 2.4	LT 2.4	25.00	LT 2.4	25.00	2.40	
ORGANIC COMPOUNDS									
(SEMI-VOLATILE) (ug/l)									
ALDRIN	LT 11.0	LT 11.0	LT 11.0	LT 11.0	LT 11.0	LT 11.0	LT 11.0	11.00	
BICYCLOHEPTADIENE	LT 3.4	LT 3.4	LT 3.4	LT 3.4	LT 3.4	LT 3.4	LT 3.4	3.40	
DIBROMOCHLOROPROPANE	LT 3.3	LT 3.3	LT 3.3	LT 3.3	LT 3.3	LT 3.3	LT 3.3	3.30	
DIELDRIN	4.40	LT 4.4	LT 4.4	LT 4.4	LT 4.4	LT 4.4	4.40	4.40	
DIISOPROPYLMETHYL PHOSPHONATE	LT 15.0	500.00	500.00	LT 15.0	3000.00	1000.00	1250.00	15.00	
1,4-DITHIANE	LT 6.1	200.00	35.00	LT 6.1	80.00	28.00	85.75	6.10	
ENDRIN	LT 10.0	LT 10.0	LT 10.0	LT 10.0	LT 10.0	LT 10.0	LT 10.0	10.00	
ISODRIN	LT 8.3	LT 8.3	LT 8.3	LT 8.3	LT 8.3	LT 8.3	LT 8.3	8.30	
CHLOROPHENYLMETHYL SULFIDE	LT 5.5	LT 5.5	LT 5.5	LT 5.5	LT 5.5	LT 5.5	LT 5.5	5.50	
CHLOROPHENYLMETHYL SULFOXIDE	700.00	700.00	500.00	LT 24.0	LT 24.0	200.00	525.00	24.00	
CHLOROPHENYLMETHYL SULFONE	12.00	LT 4.9	LT 4.9	LT 4.9	LT 4.9	LT 4.9	12.00	4.90	
1,4-OXATHIANE	LT 12.0	15.00	LT 12.0	LT 12.0	13.00	LT 12.0	14.00	12.00	

NOTES:

1. VALUES SHOWN ARE AVERAGES OF HITS (CONCENTRATIONS ABOVE CRL'S AND MDL'S).
2. CRL = USATHAMA ANALYTICAL METHOD CERTIFIED REPORTING LIMIT.
3. MDL = EPA ANALYTICAL METHOD DETECTION LIMIT.

BASIN A-NECK IRA
TABLE 1 - MKE SAMPLING PROGRAM
RESULTS OF GROUNDWATER ANALYSIS
(CONTINUED)

ANALYTE	WELL NO. 35506	WELL NO. 35509	WELL NO. 35510	WELL NO. 26501	WELL NO. 26502	WELL NO. 26503	AVERAGE (NOTE 1)	CRL (NOTE 2)	MDL (NOTE 3)
INORGANIC ELEMENTS & COMPOUNDS (mg/l)									
CALCIUM	3.20	190.00	154.00	144.00	492.00	563.00	257.70	0.50	
MAGNESIUM	0.10	53.70	38.30	52.80	169.00	197.00	85.15	0.51	
SODIUM	906.00	600.00	583.00	310.00	651.00	855.00	650.83	2.80	
MANGANESE	LT .005	4.34	1.92	0.01	3.77	7.91	3.59		0.005
IRON	LT .15	LT .15	LT .15	LT .15	LT .15	LT .15	LT .15		0.15
BARIUM	0.02	0.03	0.05	0.07	0.07	0.03	0.04		0.02
STRONTIUM	0.03	2.65	2.26	2.90	5.40	7.52	3.46		0.02
NICKEL	0.02	0.02	0.02	LT .02	0.02	0.03	0.02		0.02
CHLORIDE	420.00	320.00	360.00	300.00	1400.00	1400.00	700.00	1.38	
SULFATE	330.00	1300.00	950.00	320.00	810.00	1700.00	901.67	23.30	
NITRATE	2.10	0.40	1.70	32.00	6.50	1.20	7.32		0.10
PHOSPHATE	0.93	0.16	0.02	0.11	0.06	0.04	0.22		0.001
HYDROXIDE	30.00	LT 1.0	LT 1.0	LT 1.0	LT 1.0	LT 1.0	30.00		1.00
CARBONATE	684.00	LT 1.0	LT 1.0	LT 1.0	LT 1.0	LT 1.0	684.00		1.00
BICARBONATE	0.00	236.00	314.00	300.00	310.00	186.00	224.33		1.00
FLUORIDE	1.10	2.10	3.00	2.70	0.48	1.24	1.77	0.10	
SILICA	58.00	21.00	19.00	23.00	21.00	20.00	27.00		0.10
AMMONIA	1.69	0.10	0.10	0.14	0.10	0.10	0.37		0.10
WATER QUALITY PARAMETERS (as noted)									
pH	10.81	7.49	7.73	7.37	7.03	7.23	7.94		
TDS (mg/l)	2420.00	2530.00	2340.00	1540.00	4320.00	5180.00	3055.00		10.00
T. HARD (mg/l as $CaCO_3$)	24.50	734.00	582.00	606.00	1765.00	1966.00	946.25		0.10
T. ALK (mg/l as $CaCO_3$)	1230.00	194.00	257.00	246.00	254.00	153.00	389.00		1.00
TURBIDITY (NTU)	33.50	22.60	30.60	44.90	109.20	82.00	53.80		1.00
CONDUCTIVITY (MMHOS)	3515.00	3235.00	2885.00	2040.00	5555.00	5910.00	3856.67		10.00
TOC (mg/l)	52.40	16.80	15.70	18.30	13.70	14.80	21.95		1.00

NOTES:

1. VALUES SHOWN ARE AVERAGES OF HITS (CONCENTRATIONS ABOVE CRL'S AND MDL'S).
2. CRL = USATHAMA ANALYTICAL METHOD CERTIFIED REPORTING LIMIT.
3. MDL = EPA ANALYTICAL METHOD DETECTION LIMIT.

BASIN A NECK IRA
TABLE 2 - MKE SAMPLING PROGRAM
SUMMARY OF GROUNDWATER ANALYSIS
FOR WELL NOS. 35509,35510 & 26503

ANALYTE	VALUE AVERAGE(NOTE2)	VALUE RANGE
VOLATILE ORGANIC COMPOUNDS (ug/l)		
BENZENE	5.35	4.9-5.8
SEMIVOLATILE ORGANIC COMPOUNDS (UG/L)		
CHLOROPHENYLMETHYL SULFOXIDE	467.00	200-700
DIISOPROPYLMETHYL PHOSPHONATE	667.00	500-1000
1,4-DITHIANE	87.70	28-200
1,4-OXATHIANE	15.00	15
INORGANIC ELEMENTS & COMPOUNDS (ug/l)		
CALCIUM	302.00	154-563
MAGNESIUM	96.30	38.3-197
SODIUM	679.00	583-855
MANGANESE	4.70	1.92-7.91
BARIUM	0.04	0.03-0.05
STRONTIUM	4.10	2.26-7.52
NICKEL	0.02	0.02-0.03
CHLORIDE	693.00	320-1400
SULFATE	1317.00	950-1700
NITRATE	1.10	0.4-1.7
PHOSPHATE	0.07	0.02-0.16
BICARBONATE	245.00	186-314
FLUORIDE	2.11	1.24-3.0
SILICA	20.00	19-21
AMMONIA	0.10	0.1
WATER QUALITY PARAMETERS (units as noted)		
pH	7.48	7.23-7.73
TDS (mg/l)	3350.00	2340-5180
T. HARD (mg/l as CaCO3)	1094.00	582-1966
T. ALK (mg/l as CaCO3)	201.00	153-257
TURBIDITY (NTU)	45.10	22.6-82.0
CONDUCTIVITY (mmhos)	4010.00	2885-5910
TOC (mg/l)	15.80	14.8-16.8

NOTE:

1. ONLY ANALYTES WITH HITS (CONCENTRATIONS ABOVE CRL'S AND MDL'S) IN THE THREE WELLS ARE SHOWN IN THIS TABLE.
2. VALUES SHOWN ARE THE AVERAGE OF HITS (CONCENTRATIONS ABOVE CRL'S AND MDL'S)

Compared to data ("USATHAMA data") presented in Section 4.3 of the Alternatives Assessment document for the Basin A Neck IRA (summarized in Table 3) for preliminary characterization of water quality in the Basin A Neck channel, the current sampling within the narrow Basin A Neck channel found fewer organic contaminants (9 versus 15). This difference is not unexpected because the two sets of data are based on different sets of sampled wells at different time periods. Many of the wells in the USATHAMA data base are distant from the narrow Basin A Neck channel and their contribution, if any, to the quality of water in this channel is unknown. Although it is believed that the current MKE sampling data best represents current water quality conditions in the narrow Basin A Neck area, the wider range of organic contaminants detected in the past in wells within the general area of Basin A Neck justifies a conservative approach in the treatment system design. Therefore, both sets of data will be used in the analyses of the treatment system design.

3.6.3 Treatment Hydraulic Capacity

The treatment system is designed to operate at maximum and average flowrates respectively of 30 and 18 gpm as discussed in Section 3.1. Excess hydraulic capacity in the pumping, filtration and carbon adsorption systems will allow for operation of the treatment system in excess of 30 gpm for limited periods of time. The standard carbon adsorber modules selected in preliminary design as discussed herein have a hydraulic capacity of approximately 36 gpm, which represents a 100 percent margin of safety over expected treatment system flow.

3.6.4 Process Selection and Design Analysis

The Basin A Neck Decision Document specified that air stripping be considered during design as a treatment alternative for use in combination with activated carbon adsorption. Preliminary

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TABLE 3 - USATHAMA DATA BASE
SUMMARY OF GROUNDWATER ANALYSIS

ANALYTE	VALUE AVERAGE	VALUE RANGE
VOLATILE ORGANIC COMPOUNDS (ug/l)		
BENZENE	3.10	2.4-4.0
CHLOROBENZENE	5.00	2.0-6.9
CHLOROFORM	10.00	2.0-29
DICYCLOPENTADIENE	90.00	10-580
TRICHLOROETHYLENE	6.70	4.0-8.9
TETRACHLOROETHYLENE	13.00	1.9-22
SEMI-VOLATILE ORGANIC COMPOUNDS (ug/l)		
CHLOROPHENYLMETHYL SULFIDE	47.00	2.6-150
CHLOROPHENYLMETHYL SULFOXIDE	46.00	9.5-93
CHLOROPHENYLMETHYL SULFONE	1000.00	6.9-7400
DIBROMOCHLOROPROPANE	2.10	0.19-22
DIISOPROPYLMETHYL PHOSPHONATE	960.00	2.6-3000
DIELDRIN	0.51	.072-1.4
ENDRIN	0.89	0.3-2.3
1,4-DITHIANE	430.00	22-2900
1,4-OXATHIANE	58.00	8.0-290
INORGANIC ELEMENTS & COMPOUNDS (mg/l)		
ARSENIC	0.02	.006-.025
CALCIUM	360.00	31-870
CHROMIUM	0.06	.0073-.190
BICARBONATE	180.00	120-260
CHLORIDE	840.00	23-2800
FLUORIDE	2.70	1.1-5
WATER QUALITY PARAMETERS (units as noted)		
T. HARD (mg/l as CaCO3)	1500.00	90-6000
T. ALK (mg/l as CaCO3)	180.00	51-260

NOTE: ONLY ANALYTES WITH HITS (CONCENTRATIONS ABOVE CRL'S AND MDL'S) ARE SHOWN IN THIS TABLE.

design analysis indicates that air stripping is not necessary either on a cost- or safety factor-basis. The reasons for this conclusion are:

- The air stripping process is most effective in treating volatile organic compounds which were detected in relatively low concentrations in the Basin A Neck area.
- The volatile organic compounds detected in the Basin A Neck area are all amenable to removal through activated carbon adsorption.
- Air stripping requires emissions controls for the stripper offgas which creates potential operational and maintenance problems.
- Air stripping preceding activated carbon adsorption normally aids in reducing the loading on the activated carbon through removal of the volatile organic compounds. Owing to the relatively low concentrations of volatile organic compounds detected, this advantage will not be realized to any significant degree.

The effectiveness of the selected process which utilizes activated carbon adsorption stems from its ability to target and remove both volatile and semi-volatile organic compounds. The organic compounds which have been detected in the Basin A Neck area would therefore be readily treated by activated carbon adsorption alone. Provisions have been made within the treatment system for addition of air stripping equipment in the future.

The main processes of the treatment system include pre-filtration, post-filtration, and activated carbon adsorption. Design analyses of each process are discussed below.

3.6.4.1 Pre and Post-Filtration

It is evident that removal of suspended solids and especially carbon fines is paramount to the successful operation of a groundwater extraction/treatment/recharge system based on operating experience at the RMA North Boundary, Northwest Boundary and Irondale containment systems. The purpose of this section is to evaluate various conventional filtration and solids separation equipment and to recommend a pre and post-filtration system for use in the Basin A-Neck Groundwater Treatment System which offers reliability, ease of operation and ease of maintenance. The following types of filtration and solids separation equipment have been evaluated:

A. Granular Dual-Media Pressure Filters
B. Backwashable Tubular Filters
C. Cartridge Filters
D. Cyclone Separators
E. Bag Filters

A. Granular Dual-Media Pressure Filters

Granular dual-media pressure filters generally consist of vertical cylindrical pressure tanks containing two types of granular filter media, usually an anthracite layer over a sand layer. The filtered water is collected by an underdrain system that distributes flow across the bed during service and backwash. The dual layered media as described provides for decreasing porosity in the direction of flow that allows greater penetration of solids into the filter bed. The result is longer filter runs for this type of filter than a single media filter. A polyelectrolyte filter aid is often fed upstream of the filter to enhance its solids removal efficiency. The pressure versus gravity mode of operation allows for a closed filter system which is desirable when dealing with wastewater containing volatile organic contaminants.

This type of filter is applicable for removal of suspended solids in the 5 to 50 mg/l range and is capable of producing water of less than 0.5 NTU turbidity. Hydraulic loading rates of 4 to 10 gpm/ft^2 are typical and backwash is generally performed at rates of 10 to 15 gpm/ft^2.

Dual-media filters have a distinct advantage over the other filters considered in that longer filter runs are possible due to the higher degree of solids storage within the filter media. However, it has the disadvantage of requiring a relatively large quantity of water to backwash and clean the filter media. The backwash wastewater containing high concentrations of solids requires treatment such as coagulation and sedimentation prior to recycling into the groundwater treatment system.

B. Backwashable Tubular Filters

Backwashable tubular filters consist of tubular filter elements contained in a pressure vessel. The tubular filter elements can be an alloy wire wound tube or a cloth covered perforated tube. Backwash is performed by reversing the flow through the tubes. A precoat or body feed such as diatomaceous earth is usually required to extend filter runs and to effectively remove solids down to 5 microns in size.

This type of filter is generally applicable to water of relatively low suspended solids concentration (<50 mg/l). Operating experience at the RMA Northwest Boundary Containment System has indicated a susceptibility by this filter to plugging by carbon fines. This plugging resulted in a very high frequency of backwashing.

C. Cartridge Filters

Cartridge filters utilize disposable filter elements housed in a pressure vessel for suspended solids removal. The filter cartridges are generally tubular fiber or tubular spiral wound in construction. The most common filter element materials of construction are cellulose and polypropylene.

This type of filter is generally applicable to water of relatively low suspended solids (<50 mg/l) and is capable of removing solids down to 1 micron in size. Use of 1 micron filter elements often results in excessively short filter runs and frequent cartridge replacement. Unless the filter influent is extremely low in suspended solids, a minimum 10 micron filter element is generally recommended. The RMA North Boundary, Northwest Boundary and Irondale containment systems all currently utilize cartridge filters for pre and post-filtration. Operating experience at these facilities has indicated this type of filter to be reliable in the removal of suspended solids. The one disadvantage associated with the use of this type of filter is the large quantity of filter cartridges generated which require disposal.

D. Cyclone Separators

Cyclone Separators utilize centrifugal action for the removal of suspended solids. Raw water enters a pressure vessel and is accelerated in a circular motion which imparts a centrifugal force on the suspended material. The resultant effect is separation of the suspended material from the liquid. The filtrate is discharged from the top of the vessel while the suspended material settles to the bottom of the unit and is discharged on an intermittent or continuous basis.

Owing to its principle of operation, the effectiveness of cyclone separators is highly susceptible to changes in flowrate. As a result, proper selection and sizing of these units during design is imperative. Removal capabilities down to 40 micron in size has been reported. The RMA North and Northwest Boundary containment systems are currently in the process of installing this type of solids separation equipment for removal of fines from virgin carbon. There are no operating data from the new installations available as of the issuance of this report. The main advantages of using cyclone separators are the relatively small quantity of solids bleed off water that requires further treatment and the lack of filter elements that require disposal. Its disadvantages result from ineffective removal of small particles and its sensitivity to changes in influent characteristics such as flow and suspended solids concentration.

E. Bag Filters

Bag filters utilize reusable filter bags contained in a pressure vessel for the removal of suspended solids. A common filter bag material of construction is polypropylene. Upon high differential pressure across the unit, the filter bags are removed and manually cleaned through backflushing with a high-pressure nozzle.

This type of filter is generally better suited to waters of relatively low suspended solids content (<50 mg/l). Filter bags are available for removal of solids down to 1 micron in size. Bag filters are well suited to use as guard filters and secondary filters for the protection of downstream processes. Inherent advantages of this filter are the relatively low quantities of back flush water generated which requires further treatment and the lack of disposable filter elements which require disposal. However, backflushing of the filter bags is very labor intensive. Consequently, bag filters should not be used for water containing high concentrations of solids. Bag filters have been successfully used as guard filters at all three RMA boundary containment systems.

F. Filter Process Selection

Granular dual-media pressure filtration is selected as the process of choice for both pre and post-filtration. This type of filtration process is advantageous for the reasons discussed below.

mounted package unit complete with filter vessels, filter media, automatic valves, interconnecting piping, electrical

- Granular dual-media pressure filtration is a proven process for the removal of suspended solids and turbidity. With proper chemical pretreatment, this process has been shown capable of removing particles down to 5 micron in size and of reducing turbidity to below 0.5 NTU.

- Granular dual-media pressure filtration does not require manual handling of the filtration medium. This is especially important in pre-filtration considering the presence of volatile organic compounds in the filter influent.

- Granular dual-media pressure filtration does not generate filter medium waste products such as filter cartridges that require disposal.

- Granular dual-media pressure filtration provides much greater storage of suspended solids than other backwashable filters that utilize screens or fabric as a filter medium. As a result, this type of filter generates less backwash wastewater since less frequent backwashing is required.

In addition to granular dual-media pressure filtration, bag-type filters will be utilized for the post-filtration process. The bag-type filters will operate downstream of the dual-media filters and will provide a secondary barrier against solids pass through from the treatment system. This is an especially important safeguard since any solids leakage may cause plugging of the recharge trenches.

3.6.4.2 Activated Carbon Adsorption

Activated carbon adsorption is utilized for the removal of volatile and semi-volatile organic compounds from the groundwater. Carbon adsorption modules, each containing approximately 2000 pounds of carbon, were selected for this process. Upon exhaustion of the carbon bed, the modules are returned to a permitted carbon regeneration facility and replaced with modules containing fresh carbon. The modules containing spent carbon are regenerated by the regeneration facility. The use of modular adsorbers affords certain advantages over a system utilizing permanent adsorber vessels which require equipment for virgin carbon storage, spent carbon storage, virgin carbon defining and carbon transport. These advantages are summarized as follows.

A. The modular adsorbers are less expensive in terms of capital expenditure.

B. No carbon fines from handling of carbon are generated on site.

C. The modular adsorbers minimize the exposure of workers onsite to contaminated carbon since no carbon handling systems are required.

Hydraulic loading and pressure drop considerations dictate selection of the size of a standard carbon adsorber module, in turn setting the quantity of carbon contained within each module. Therefore, the design analysis involves evaluating predicted performance of one or more standard module units in series using the influent groundwater quality data discussed in Section 3.6.2. The key performance variable is carbon life as set by the limiting organic compound. In view of the large safety factor inherent in the design, the breakthrough concentrations for all compounds are set at the respective CRL values. Since CRL's vary with laboratory and analytical technique, a survey was performed to determine the lowest value for each compound to be used as the respective treatment level. The lowest CRL values, are listed in Table 4 for each compound.

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TABLE 4 - CARBON ADSORBER DESIGN ANALYSIS

PREDICTED CARBON BED LIFE AND CAPACITY FOR ORGANIC COMPOUNDS

FOR USATHAMA WATER QUALITY DATA

ORGANIC COMPOUND	ADSORBER INFLUENT CONC. (ug/l)	TARGET CONC. (ug/l)	TIME TO BREAKTHRU (days)
SEMI-VOLATILE			
CHLOROPHENYMETHYL SULFIDE	47	1	30,000
CHLOROPHENYLMETHYL SULFOXIDE	46	2.6	15,300
CHLOROPHENYLMETHYL SULFONE	1000	2.6	1,230
DIBROMOCHLOROPROPANE	2.1	0.11	145,000
DIISOPROPYLMETHYL PHOSPHONATE	960	10	1,900
DIELDRIN	0.51	0.05	6,560,000
ENDRIN	0.89	0.05	3,510,000
1,4-DITHIANE	430	2	760
1,4-OXATHIANE	58	2.6	600
VOLATILE			
BENZENE	3.1	0.09	21,400
CHLOROBENZENE	5	0.6	49,400
CHLOROFORM	10	0.5	4,460
DICYCLOPENTADIENE	90	1.5	17,100
TRICHLOROETHYLENE	6.7	0.06	18,900
TETRACHLOROETHYLENE	13	1.3	36,400

NOTE: TARGET CONCENTRATIONS HAVE BEEN SET AT THE MINIMUM CRL'S FOR EACH COMPOUND.

Calculations to determine the time to breakthrough were based on the Freundlich isotherm equation. Theoretical Freundlich isotherm parameters (K and 1/n) were calculated for each compound using the Polanyi correlation theory (Crittenden, J.C. et. al., 1986, Correlation of Aqueous Adsorption Isotherms for Hydrophobic Compounds using the Polanyi Potential Theory) assuming the use of a commercially available carbon.

The results of the breakthrough calculations for USATHAMA and MKE water quality data are presented respectively in Tables 4 and 5. Included in the Table are the time (days) and capacity (lb/1000 gallons) to breakthrough for each organic compound. The values in Tables 4 and 5 are predicated on the use of one carbon adsorption module for the removal of organic compounds. In order to predict the operating life of an adsorption module, a conservative approach is used whereby the carbon adsorption capacities of each compound are summed to determine the total adsorption capacity of the carbon bed at breakthrough. The total adsorption capacity as calculated using the USATHAMA water quality data is 0.22 lb/1000 gallons which equates to a carbon bed life of approximately 210 days for operation at the maximum (30 gpm) design flowrate. Assuming a typical design carbon bed life of 3 months, this calculated bed life represents a 2.3 safety factor with respect to adsorption capacity. The actual changeout requirement of an adsorption module will be determined through periodic sampling of the treated effluent to determine the occurrence of contaminant breakthrough.

The design analysis as discussed above was repeated using the MKE water quality data and the results are presented in table 5. The resultant total adsorption capacity of the carbon bed is 0.095 lb/1000 gallons which equates to a carbon bed life of approximately 490 days for operation at the maximum design (30 gpm) flowrate. Again, assuming a typical design carbon bed life of 3 months, this calculated bed life represents a 5.4 safety factor with respect to adsorption capacity.

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TABLE 5 - CARBON ADSORBER DESIGN ANALYSIS
PREDICTED CARBON BED LIFE AND CAPACITY FOR ORGANIC COMPOUNDS
FOR MKE WATER QUALITY DATA

ORGANIC COMPOUND	ADSORBER INFLUENT CONC. (ug/l)	TARGET CONC. (ug/l)	TIME TO BREAKTHRU (days)
SEMI-VOLATILE			
CHLOROPHENYLMETHYL SULFOXIDE	467	2.6	2,290
DIISOPROPYLMETHYL PHOSPHONATE	667	10	2,600
1,4-DITHIANE	88	2	2,340
1,4-OXATHIANE	15	2.6	1,360
VOLATILE			
BENZENE	5.4	0.09	14,500

NOTE: TARGET CONCENTRATIONS HAVE BEEN SET AT THE MINIMUM CRL'S FOR EACH COMPOUND.

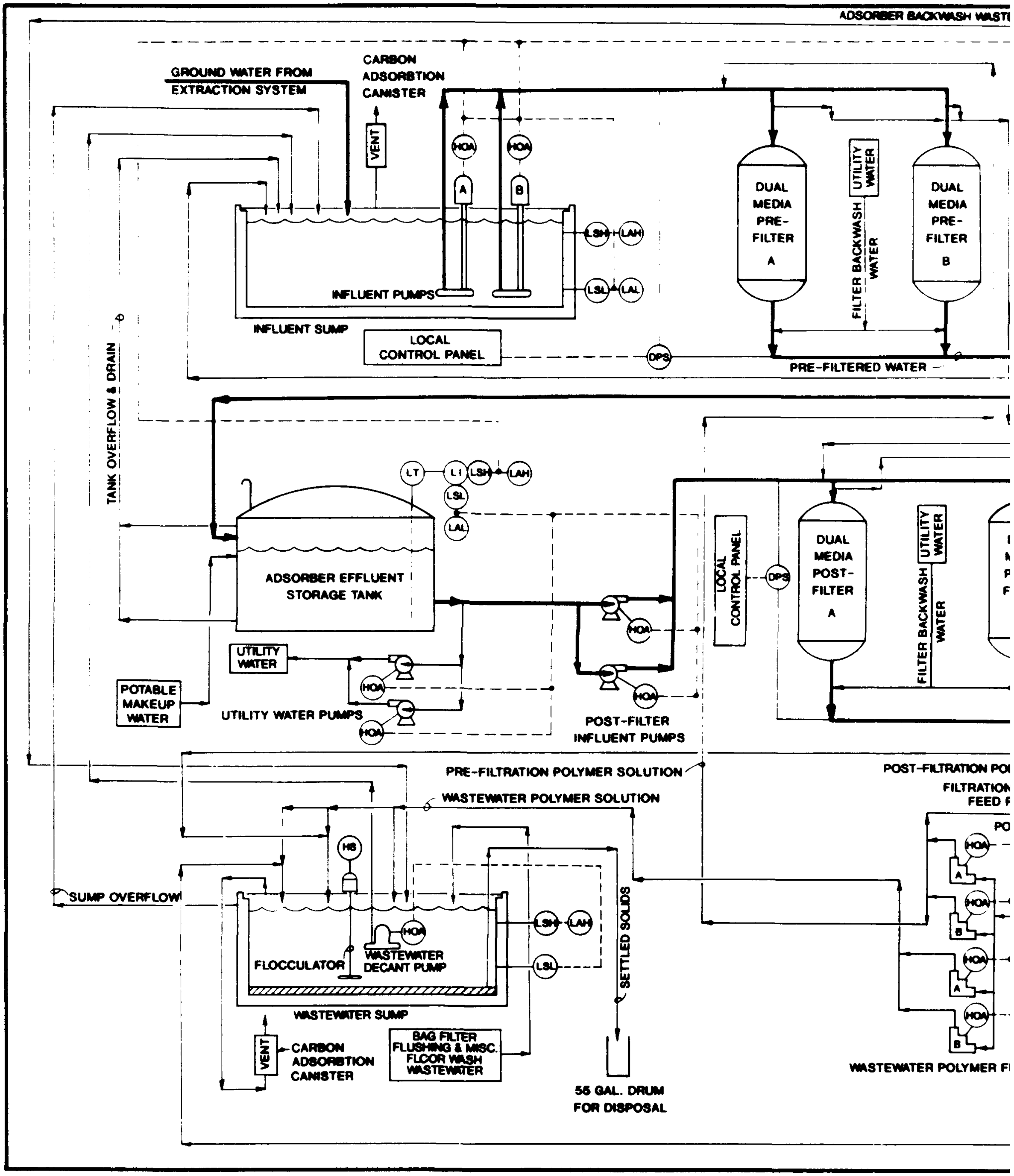
Although the design analyses are predicated on adsorption with one module, the treatment system utilizes two 2000 pound adsorption modules in series. This process configuration allows for operation of the upstream adsorption module to exhaustion while providing a second adsorption module to act as a safeguard against pass through of organic compounds from the system. Once breakthrough of an organic compound from the first stage adsorber has been verified through sampling and analysis, the first stage adsorber is replaced with the second stage adsorber and the second stage adsorber is replaced with a spare adsorption module containing virgin or regenerated carbon. The resultant effect is effective utilization of the carbon bed while providing a significant safety factor in terms of adsorption capacity.

3.6.5 Groundwater Treatment System Process Description

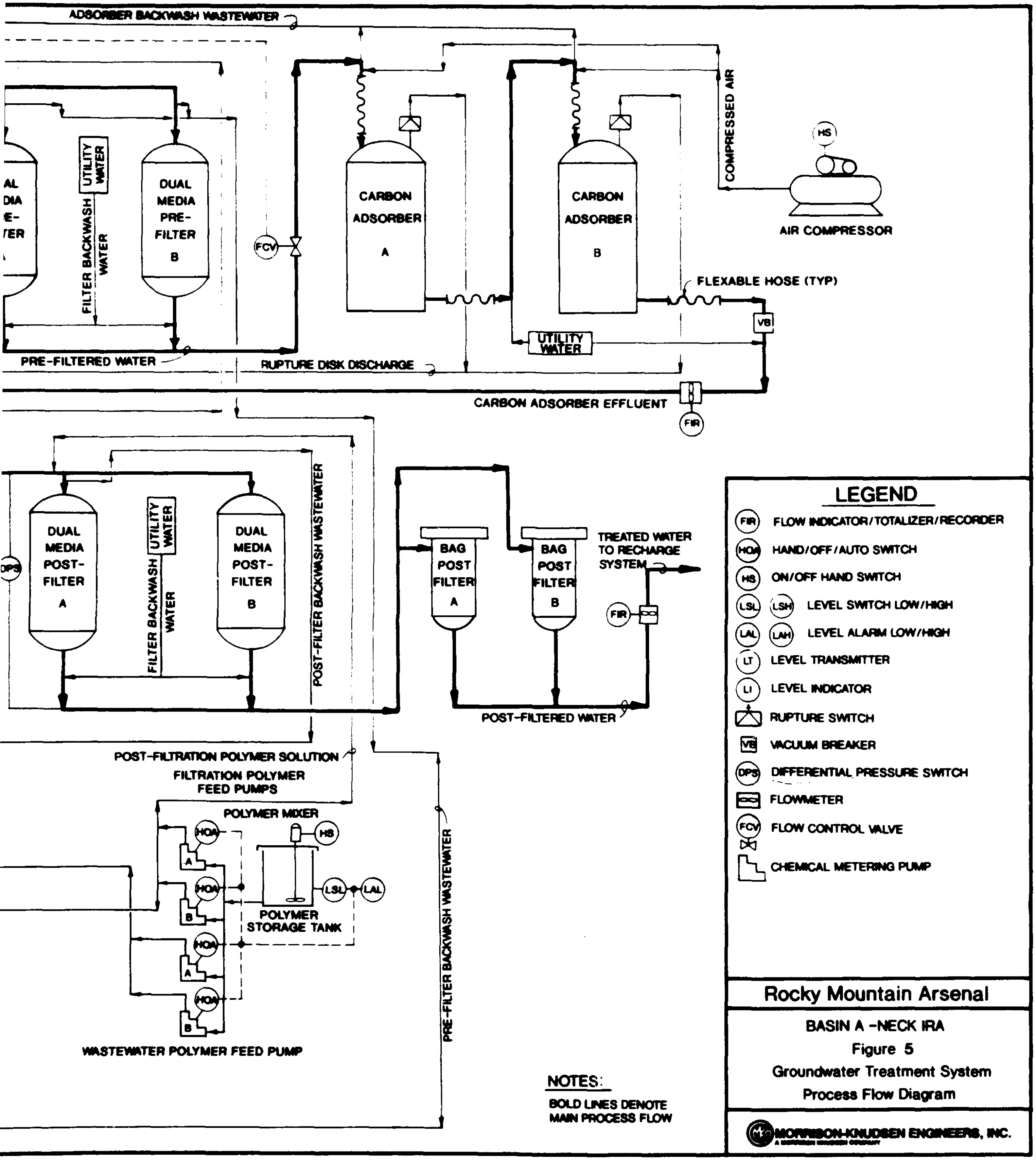
The processes of the Basin A Neck Groundwater Treatment System include flow equalization, pre-filtration, activated carbon adsorption/adsorber effluent storage, post-filtration and wastewater treatment. A process flow diagram of the treatment system is shown on Figure 5. Discussions of each treatment process and their interrelationships are included below.

3.6.5.1 Flow Equalization

The raw groundwater from the extraction system is collected in the influent sump which consists of a rectangular concrete tank sized to provide sufficient surge capacity for equalizing of the variable influent flow. Two vertical sump pumps (one operating and one standby) deliver the raw groundwater to the pre-filtration process at a constant flowrate. Low level in the sump, as sensed by a level switch, automatically shuts down the operating pump. High level in the adsorber effluent storage tank also automatically shuts down the operating pump. The sump is totally enclosed and is vented through a vapor phase activated carbon adsorption canister.



ADSORBER BACKWASH WAST
GROUND WATER FROM EXTRACTION SYSTEM
CARBON ADSORBTION CANISTER
VENT
HOA
A
B
LSH
LAH
LSL
LAL
INFLUENT PUMPS
INFLUENT SUMP
LOCAL CONTROL PANEL
DPS
DUAL MEDIA PRE-FILTER A
DUAL MEDIA PRE-FILTER B
UTILITY WATER
FILTER BACKWASH WATER
PRE-FILTERED WATER
TANK OVERFLOW & DRAIN
LT
LI
ADSORBER EFFLUENT STORAGE TANK
LOCAL CONTROL PANEL
DUAL MEDIA POST-FILTER A
UTILITY WATER
FILTER BACKWASH WATER
UTILITY WATER
POTABLE MAKEUP WATER
UTILITY WATER PUMPS
POST-FILTER INFLUENT PUMPS
PRE-FILTRATION POLYMER SOLUTION
POST-FILTRATION PO
FILTRATION
FEED F
PO
WASTEWATER POLYMER SOLUTION
HS
SUMP OVERFLOW
SETTLED SOLIDS
FLOCCULATOR
WASTEWATER DECANT PUMP
WASTEWATER SUMP
VENT
CARBON ADSORBTION CANISTER
BAG FILTER FLUSHING & MISC. FLOOR WASH WASTEWATER
55 GAL. DRUM FOR DISPOSAL
WASTEWATER POLYMER F



Rocky Mountain Arsenal

BASIN A -NECK IRA

Figure 5

Groundwater Treatment System

Process Flow Diagram

The influent sump also collects various process streams from the treatment system. These include: 1) wastewater sump overflow; 2) clarified decant water from the wastewater sump; 3) drainage/overflow from the adsorber effluent storage tank; and 4) discharge resulting from overpressurization of the carbon adsorber modules and filters.

3.6.5.2 Pre-Filtration

Pre-filtration involves the use of dual-media (anthracite and sand) pressure filters for the removal of suspended solids from the raw groundwater pumped from the influent sump. This pre-filtration process serves to protect the activated carbon adsorbers from plugging and fouling by suspended material.

Dual-media pressure filtration utilizes two, 100 percent capacity pressure filters in parallel, with one filter in operation while the second filter is undergoing backwash or on standby. High differential pressure across the filter bed as sensed by a differential pressure switch signals the need for backwash of the operating filter. At this time, flow is automatically switched to the standby filter. Once the need for backwash of a filter is indicated, an operator must manually initiate backwash by starting the utility water pump and actuating a momentary contact pushbutton. The filter valves are then automatically positioned and the filter is backwashed for a preset time. Upon completion of backwash, the filter valves are automatically placed in the service positions and the filter is put on standby status. The filters are supplied as a skid mounted package unit complete with filter vessels, filter media, automatic valves, interconnecting piping, electrical connections, instrumentation, and controls housed within a centralized control cabinet.

A polymer is added to the filter influent to improve filtration efficiency. The polymer feed system consists of a polymer storage tank, two polymer feed pumps, and an in-line static mixer. The polymer storage tank is common to the post-filtration and wastewater polymer feed systems while the polymer feed pumps are shared with the post-filtration polymer feed system. The feed pumps, one in operation and the other on standby, meter polymer to a point upstream of the static mixer located in the filter influent header. Stroke adjustment is provided on the metering pump to control the feed dosage.

Filter backwash water is supplied by the utility water pumps which take suction from the treated water storage tank. Filter backwash wastewater is discharged to the wastewater sump. Prior to discharging into the sump, a polymer can be added to the wastewater to aid in flocculation and sedimentation of the suspended solids.

3.6.5.3 Activated Carbon Adsorption/Adsorber Effluent Storage

The pre-filtered water is next treated through two modular carbon adsorbers in series for the removal of volatile and semi-volatile organic compounds. Each adsorber consists of a pressure vessel charged with approximately 2000 pounds of carbon complete with inlet connection, outlet connection, underdrain system, rupture disk and access manway. A downflow mode of operation is recommended by the manufacturer for this type of adsorber. Influent enters the top of the adsorber, passes through the carbon bed and is collected by underdrain piping which discharge to an effluent header exiting the bottom of the adsorber. The inlet and outlet connection of each adsorber are equipped with quick disconnect hose fittings to facilitate removal and replacement of the adsorber module.

Downflow operation through an adsorber tends to compress the carbon bed and entrap solids which results in an increase in head loss across the bed. Under these conditions, periodic backflushing of the carbon bed is necessary to restore the headloss to an acceptable level. This is accomplished by reversing flow through the bed at a higher rate than the service flowrate using water as supplied by the utility water pumps. The resultant effect is removal of entrapped solids and re-suspension of the compacted carbon bed. Each adsorber is piped to be backflushed manually and it is anticipated that the required frequency of backflush will be on the order of once per week. Operation of the adsorbers is terminated during the backflushing process which has a duration of approximately 10 minutes per adsorber. The backflush water is discharged to the wastewater sump for removal of suspended material.

The replacement of adsorber modules is predicated on the occurrence of either of two conditions. The first is exhaustion of the carbon bed resulting from adsorption of organic contaminants. The second is excessive head loss across the carbon bed which is not reversible through backflushing. It is anticipated that the latter will control changeout frequency of the adsorber modules.

Under normal operation, exhaustion is defined as the breakthrough of a control organic compound from the first stage adsorber. Defining exhaustion in this manner affords a great deal of protection against contaminant leakage from the system since a substantial portion of the adsorptive capacity of the second stage adsorber still remains at exhaustion. Once exhaustion has been verified through analysis of the treated water, the first stage adsorber is removed and replaced by the second stage adsorber. The second stage adsorber is then replaced with one of two spare carbon adsorber modules which contain virgin or regenerated carbon. Use of the module containing fresh carbon as the second stage adsorber is another precautionary measure against breakthrough of the control compound.

Each adsorber is equipped with a rupture disk for protection against damage to the carbon containment vessel. The need to replace an adsorber module occurs when the head loss across the bed approaches the rupture disk set pressure and this head loss is not reversible through backflushing. The head loss across the carbon bed is determined by pressure gauges located on the inlet and outlet of each adsorber. Once the need for replacement has been determined, the adsorber is removed and replaced with one of two spare carbon adsorber modules containing virgin or regenerated carbon. If the rupture disk set pressure has been exceeded, the water released from the adsorber is discharged to the influent sump.

Replacement of an adsorber proceeds initially with isolation of the adsorber and pressurizing of the vessel with compressed air as supplied by a tank mounted air compressor. The air displaces the water within the vessel which is discharged to the adsorber effluent storage tank. The module which has been emptied of its liquid is of the proper weight to be transported with a forklift. The flexible hoses on the inlet and outlet connections are disconnected and the module is moved to a location for storage using a forklift. A new adsorber module is moved in place using a forklift and the inlet and outlet connections are connected to the influent and effluent hoses. Prior to being placed in service, the new adsorber is backflushed to remove any carbon fines which have been generated through shipment.

Surges in the influent to the carbon adsorbers have the effect of producing carbon fines in the adsorber effluent. In order to prevent these surges, a slow acting flow control valve is installed in the carbon adsorber influent piping. This valve opens and closes in conjunction with the starting and stopping of the influent pumps.

A flowmeter located in the carbon adsorber effluent header measures the carbon adsorber treated water flowrate and provides a signal to a remote indicator which displays and records the flowrate and totalized volume of treated water. The information recorded is useful in establishing the frequency for changeout of carbon adsorber modules.

The relatively low pressure rating of the adsorber modules requires re-pumping of the carbon adsorber effluent to the post-filtration process. Consequently, the carbon adsorber effluent is stored in the adsorber effluent storage tank and pumped to the post-filters via the post-filter influent pumps. The tank also provides suction for the utility water pumps which supply utility water for various uses in the plant including backwashing of the pre-/post-filters and backflushing of the carbon adsorbers. A potable water supply is available as makeup to the tank in the event that utility water demands exceed the adsorber effluent storage capacity and/or the adsorber effluent flowrate. Low level in the tank as sensed by a level probe automatically shuts down the operating post-filter influent pump and utility water pump.

3.6.5.4 Post-Filtration

Post-filtration involves the use of dual-media (anthracite and sand) pressure filters followed by bag-type guard filters for the removal of suspended solids from the carbon adsorber effluent. This post-filtration process serves to protect the recharge trenches from plugging with suspended material.

Dual-media pressure filtration utilizes two, 100 percent capacity pressure filters in parallel, with one filter in operation while the second filter is undergoing backwash or on standby. High differential pressure across the filter bed, as sensed by a differential pressure switch, signals the need for backwash of the operating filter. At this time, flow is automatically switched to the standby filter. Once the need for backwash of a filter is indicated, an operator must manually initiate backwash by starting the utility water pump and actuating a momentary contact pushbutton. The filter valves are then automatically positioned and the filter is backwashed for a preset time. Upon completion of backwash, the filter valves are automatically placed in the service positions and the filter is put on standby status. The filters are supplied as a skid mounted package unit complete with filter vessels, filter media, automatic valves, interconnecting piping, electrical connections, instrumentation, and controls housed within a centralized control cabinet.

A polymer is added to the filter influent to improve filtration efficiency. The polymer feed system consists of a polymer storage tank, two polymer feed pumps, and an in-line static mixer. The polymer storage tank is common to the pre-filtration and wastewater polymer feed systems while the feed pumps are shared with the pre-filtration polymer feed system. The feed pumps, one in operation and the other on standby, meter polymer to a point upstream of the static mixer located in the filter influent header. Stroke adjustment is provided on the metering pump to control the feed dosage.

Filter backwash water for the dual-media pressure filters is supplied by the utility water pumps which take suction from the treated water storage tank. Filter backwash wastewater is discharged to the wastewater sump. Prior to discharge into the sump, a polymer can be added to the wastewater to aid in flocculation and sedimentation of the suspended solids.

The bag-type guard filters provide a secondary defense against pass through of solids from the treatment system. Two filters are utilized with one filter in operation while the other filter is undergoing bag cleaning/replacement or is on standby. The need for bag cleaning/replacement is indicated by a high differential pressure across the filter, as measured by a differential pressure gauge. The 10 micron filter bags are physically removed from the filter vessel and backflushed to remove the entrapped solids. This backflushing is performed at a designated station equipped with a high pressure hose and bag holder. The bags are replaced if visual examination indicates damage. The backflushing wastewater is channeled to the wastewater sump.

A flowmeter located in the bag filter effluent header measures the final treated water flowrate and provides a signal to a remote indicator which displays and records the flowrate and totalized volume of treated water.

3.6.5.5 Wastewater Treatment

Several wastewater streams are generated by the treatment plant which require treatment for removal of carbon fines and/or suspended solids. These are: 1) wastewater from backwashing of the pre and post-filters; 2) wastewater from backflushing of filter bags; 3) wastewater from washdown of the treatment area; and 4) wastewater from backflushing of the carbon adsorbers. These wastewaters are collected in the wastewater sump consisting of a rectangular concrete basin that serves as both a holding tank and batch sedimentation basin. Once the tank is full, plant operation is scheduled such that no additional wastewater is introduced for a preset period of time. The contents of the tank are allowed to undergo sedimentation for separation of the suspended solids from the wastewater. Upon determination that adequate sedimentation has been achieved, the decant of the sump is pumped at a low flowrate to the influent sump where it is recycled through the treatment system. Periodically, the sump is completely dewatered and the solids that have accumulated are educted or vacuumed into drums for disposal. The sump is totally enclosed and is vented through a vapor phase carbon adsorption canister.

Provisions are included for addition of polymer to the wastewater to enhance sedimentation of the suspended solids. The polymer feed and mixing system includes two polymer feed pumps, a polymer storage tank, and a vertical shaft flocculator located in the sump. The polymer storage tank is common to the pre and post-filtration polymer feed systems. One polymer feed pump is normally in operation while the second pump is on standby. The operating feed pump meters polymer injected into the sump where it is uniformly mixed with the sump contents by the vertical shaft flocculator. If required, polymer can be injected in-line directly into the backwash wastewater discharge piping of the pre- and post-filters.

3.6.6 Instrumentation

The following is a summary of the instrumentation required for the treatment system including the function that each provides.

INSTRUMENT	FUNCTION
Influent sump high level switch	Actuates high level alarm light on main control panel and shuts down extraction well pumps
Influent sump low level switch	Shuts down operating influent pump and actuates low level alarm light on control panel
Pre-filter differential pressure switch	Automatically positions valves to switch flow from operating filter to standby filter and actuates backwash light on filter vendor supplied local control panel
Post-filter differential pressure switch	Automatically positions valves to switch flow from operating filter to standby filter and actuates backwash light on filter vendor supplied local control panel
Adsorber effluent flowmeter	Measures adsorber effluent flow and provides input signal to adsorber effluent flow indicator/totalizer/recorder
Adsorber effluent flow indicator/totalizer/recorder	Indicates, totalizes and records adsorber effluent flow on main control panel
Adsorber effluent storage tank level probe	Measures level in storage tank and provides input signal to adsorber effluent storage tank level switches and level indicator
Adsorber effluent storage tank level indicator	Indicates storage tank level on main control panel

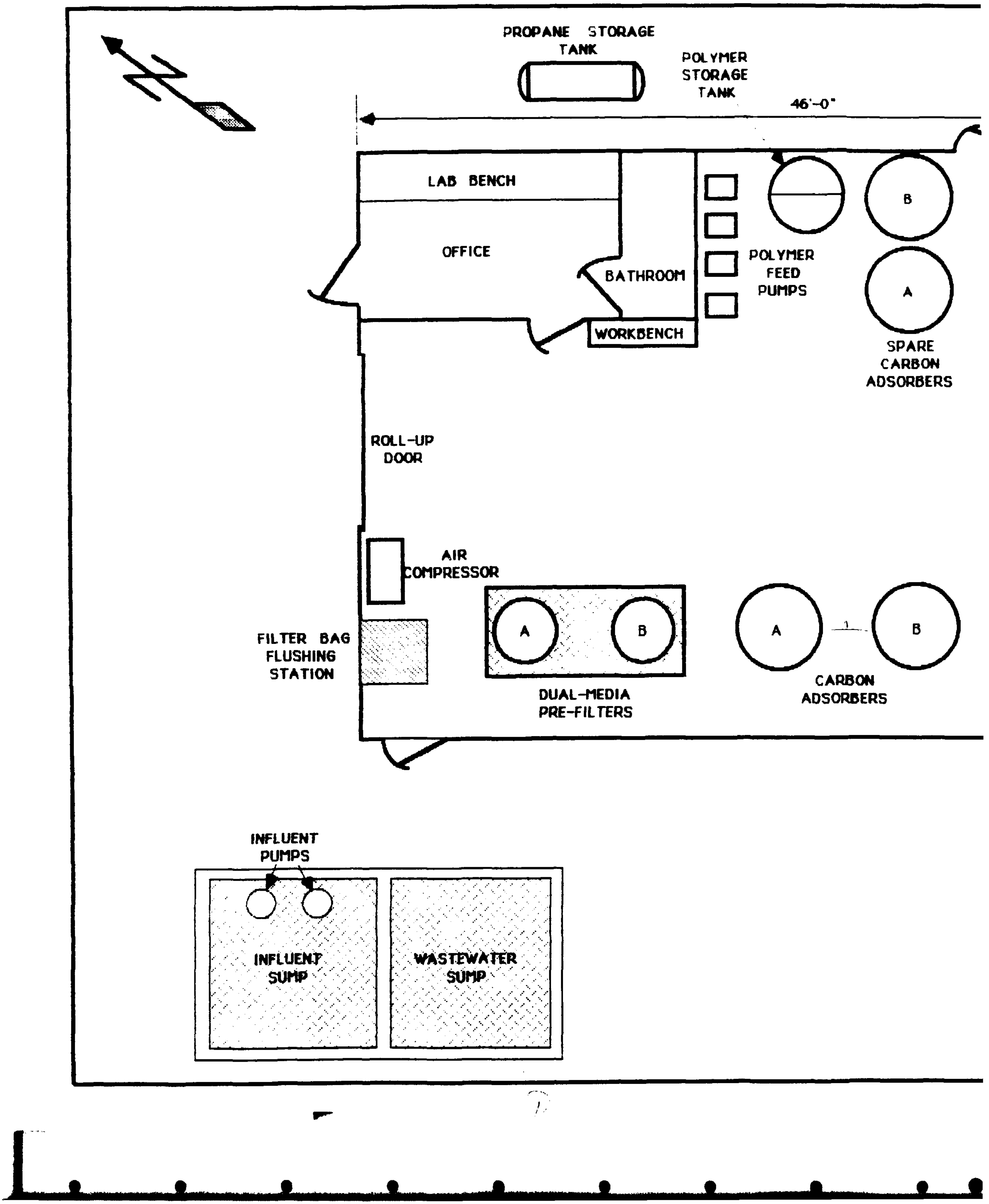
Adsorber effluent storage tank high level switch	Shuts down operating influent pump and actuates high level alarm light on main control panel
Adsorber effluent storage tank low level switch	Shuts down operating utility water pump and post-filter influent pump ~~and actuates~~ low level alarm light on main control panel
Polymer storage tank low level switch	Shuts down operating polymer feed pump and actuates low level alarm light on main control panel
Treated water flowmeter	Measures treated water flowrate and provides input signal to the treated water flow indicator/totalizer/recorder
Treated water flow indicator/totalizer/recorder	Indicates, totalizes and records treated water flow on main control panel
Wastewater sump low level switch	Shuts down wastewater decant pump
Wastewater sump high level switch	Actuates high level alarm light on main control panel

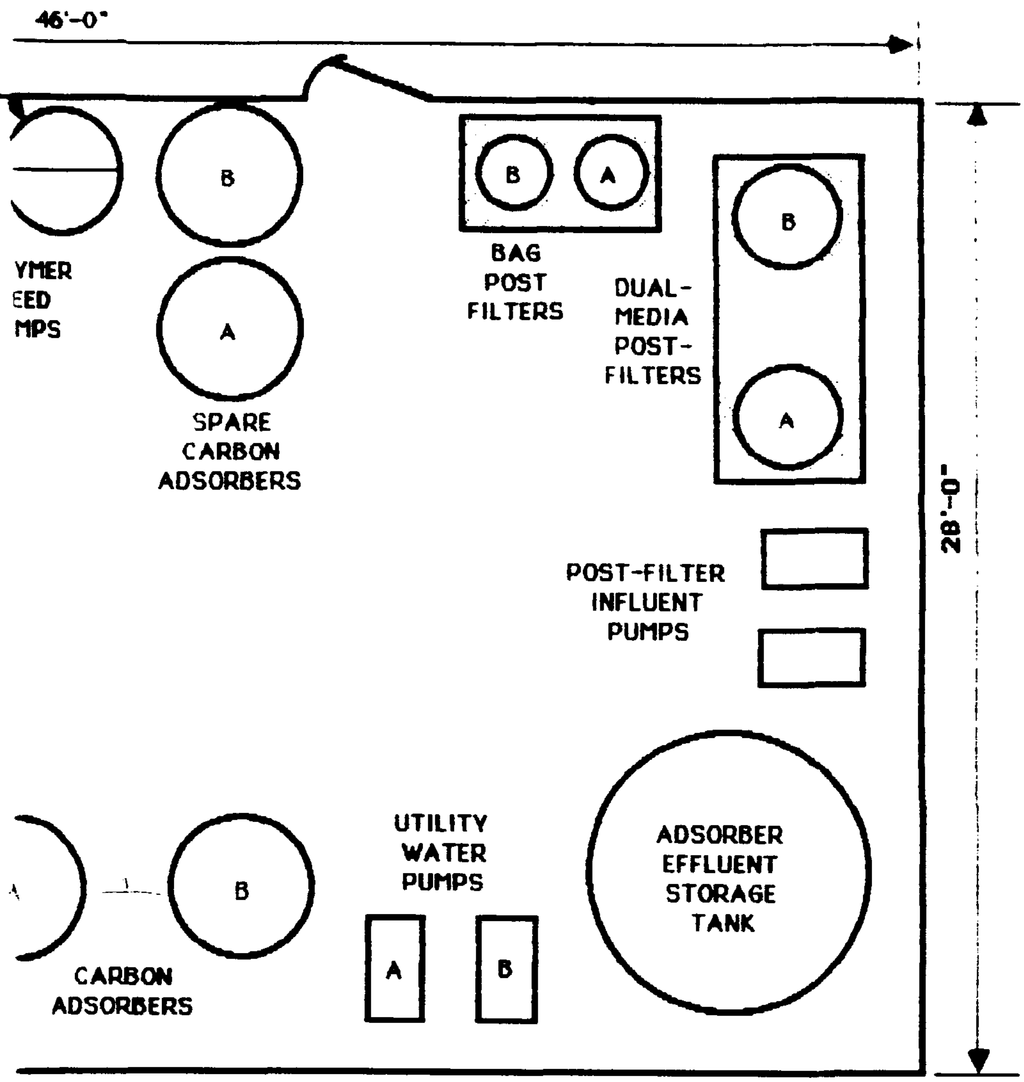
For all instrumentation indicated above as well as instrumentation required for the groundwater extraction and recharge system, additional contacts are provided to allow for future remote readout and recording of system functions.

The groundwater treatment system is designed to operated continuously but is manned for only eight hours per day. A telephone dialer system is provided to alert off-duty personnel of operational upsets within the plant.

3.6.7 Facility Description

A general arrangement of the treatment building, influent sump and wastewater sump is shown on Figure 6. As shown, a building of approximately 46 by 28 feet in size is required to contain the equipment of the treatment system. The building and


PROPANE STORAGE TANK
POLYMER STORAGE TANK
46'-0"
LAB BENCH
OFFICE
BATHROOM
WORKBENCH
POLYMER FEED PUMPS
B
A
SPARE CARBON ADSORBERS
ROLL-UP DOOR
AIR COMPRESSOR
FILTER BAG FLUSHING STATION
A
B
DUAL-MEDIA PRE-FILTERS
A
B
CARBON ADSORBERS
INFLUENT PUMPS
INFLUENT SUMP
WASTEWATER SUMP



Rocky Mountain Arsenal

BASIN A NECK IRA

Figure 6

Groundwater Treatment System

General Arangement Drawing

MORRISON-KNUDSEN ENGINEERS, INC.

treatment equipment is supported on a concrete foundation and concrete equipment pads are provided where required. The treatment building is completely insulated.

The treatment building contains an operator room and bathroom facilities that are maintained at a higher relative temperature than the remainder of the building. This arrangement allows for maintaining of the treatment area at a lower temperature, resulting in reduction of heating fuel consumption. All space heaters provided for the building operate on liquified propane gas and a permanent propane tank is supplied and installed outside the building. The operator room serves to house a laboratory bench, analytical equipment, and instrumentation used in monitoring and control of the treatment plant.

All valves contained within the treatment building are operable either from the building floor or an elevated platform. Elevated valves which are not operable from a platform are equipped with chain wheel operators.

3.7 UTILITIES

Electrical power for the treatment plant is available from an existing overhead power cable located along the west side of D street. The electrical supply line will be routed underground. Electrical power required for the extraction wells and instrumentation relating to the operation of the extraction/recharge system originates from the treatment plant.

A potable water supply line located along D Street serves as the potable water source for the water treatment plant. An underground potable water pipeline will be constructed to connect the existing piping to the water treatment plant.

Sanitary sewage from the treatment plant is collected in a sanitary sewer which discharges to a septic tank and leach field system. The sanitary sewer, septic tank and leach field system will be designed to Colorado Department of Health standards.

4.0 PROJECT COST ESTIMATE

The budgetary project cost estimate summary for the Basin A Neck IRA is presented in Table 6. The mobilization and demobilization costs are included in the subtotal for each construction cost item. A 25 percent contingency and fee allowance has been included in the total estimated project cost of $2,164,000.

BASIN A NECK IRA

TABLE 6 -BUDGETARY PROJECT COST ESTIMATE SUMMARY

COST ITEM	COST ($)
Extraction Wells	119,000
Slurry Wall	75,000
Recharge Trenches	276,000
Working Surface Excavation & Backfill (Benching)	135,000
Observation Wells (Piezometers)	30,000
Eighth Avenue Repair	7,000
Treatment Plant Access Road	5,000
Extraction & Recharge Forcemain Piping	30,000
Groundwater Treatment System	370,000
Utilities (Electrical Power, Potable Water, Sanitary Sewer & Septic System)	57,000
Final Engineering Design	250,000
Supervision/General Expense/ Overheads/Health & Safety	220,000
General Administration (10%)	157,000
Contingency & Fee (25%)	433,000
Total Estimated Cost	2,164,000

EXHIBIT 1

BASIN A NECK IRA GROUNDWATER TREATMENT SYSTEM
DESIGN CRITERIA

BASIN A NECK IRA
GROUNDWATER TREATMENT SYSTEM
EXHIBIT 1-DESIGN CRITERIA

TREATMENT CAPACITY:
18 gpm (average)
30 gpm (maximum)

INFLUENT SUMP:
Quantity: 1
Volume: 2900 gallons
380 ft3
Dimensions: 8'-0" x 8'-0" x 7'-6" depth
Detention Time: 160 min. @ average flow
100 min. @ maximum flow

INFLUENT PUMPS:
Quantity: 2
Type: Vertical centrifugal sump pump
Capacity per Pump: 30 gpm @ 45 psi (104 ft) TDH
Motor Horsepower: 2 hp

DUAL-MEDIA PRE-FILTERS:
Quantity: 2
Type: Vertical pressure-type with anthracite and sand media
Capacity per Filter: 30 gpm (maximum)
Vessel Diameter: 36 inches
Filter Area: 7.1 ft2
Hydraulic Loading Rate: 4.2 gpm/ft2
Backwash Flow Rate: 85 gpm
Backwash Loading Rate: 12 gpm/ft2
Backwash Duration: 10 minutes
Backwash Wastewater Volume per Backwash: 850 gallons
Depth of Media: 18 inches of anthracite
12 inches of filter sand

CARBON ADSORBERS:
Quantity: 4 total (2 operating, 2 spare)
Capacity per Adsorber: 30 gpm maximum
Type: Modular units using downflow operation
Vessel Diameter: 48 inches
Vessel Straight Side Height: 6 feet
Vessel Volume: 560 gallons
75 ft3
Weight of Carbon: 2000 pounds
Hydraulic Loading: 2.4 gpm/ft2 @ 30 gpm
1.4 gpm/ft2 @ 18 gpm

ADSORBER EFFLUENT STORAGE TANK:
Quantity: 1
Type: Vertical cylindrical with dished top
Tank Diameter: 96 inches
Tank Straight Side Height: 8 feet
Tank Volume: 3000 gallons
400 ft3
Detention Time: 170 min. @ 18 gpm
100 min. @ 30 gpm

02/01/89

BASIN A NECK IRA
GROUNDWATER TREATMENT SYSTEM
EXHIBIT 1-DESIGN CRITERIA

POST-FILTER INFLUENT PUMPS:
- Quantity· 2
- Type: E'd suction horizontal centrifugal
- Capacity per Pump: 30 gpm @ 50 psi (116 ft) TDH
- Motor Horsepower: 2 hp

DUAL-MEDIA POST-FILTERS:
- Quantity: 2
- Type: Vertical pressure-type with anthracite and sand media
- Capacity per Filter: 30 gpm (maximum)
- Vessel Diameter: 36 inches
- Filter Area: 7.1 ft2
- Hydraulic Loading Rate: 4.2 gpm/ft2
- Backwash Flow Rate: 85 gpm
- Backwash Loading Rate: 12 gpm/ft2
- Backwash Duration: 10 minutes
- Backwash Wastewater Volume per Backwash: 850 gallons
- Depth of Media: 18 inches of anthracite
  12 inches of filter sand

BAG POST-FILTERS:
- Quantity: 2
- Type: Vertical cylindrical with reusable 10 micron polypropylene bags
- Capacity per Filter: 30 gpm (maximum)

WASTEWATER SUMP:
- Quantity: 1
- Volume: 2630 gallons
  350 ft3
- Dimensions: 8'-0" x 8'-0" x 7'-6" depth

WASTEWATER FLOCCULATOR:
- Quantity: 1
- Type: Vertical shaft with 45 degree pitched blade impeller
- Motor Horsepower: 1 hp

WASTEWATER DECANT PUMP:
- Quantity: 1
- Type: Submersible Sump Pump
- Capacity per Pump: 5 gpm @ 15 ft TDH
- Motor Horsepower: .25 hp

POLYMER STORAGE TANK:
- Quantity: 1
- Type: Vertical cylindrical with split hinged cover
- Tank Diameter: 48 inches
- Tank Height: 4 feet
- Tank Volume: 300 gallons
  40 ft3
- Days of Storage: 7

BASIN A NECK IRA
GROUNDWATER TREATMENT SYSTEM
EXHIBIT 1-DESIGN CRITERIA

PRE AND POST-FILTRATION POLYMER FEED PUMPS:
Quantity: 2
Type: Positive displacement diaphragm metering pump with constant speed motors and manual stroke adjustment
Capacity: .2-2.0 gallons/hours @ 100 psi TDH
Motor Horsepower: .25 hp

POLYMER MIXER:
Quantity: 1
Type: Tank mounted with stainless steel impeller
Motor Horsepower: .5 hp

WASTEWATER POLYMER FEED PUMPS:
Quantity: 2
Type: Positive displacement diaphragm metering pump with constant speed motors and manual stroke adjustment
Capacity: .5-5 gallons/hour @ 100 psi TDH
Motor Horsepower: .25 hp

Shell Oil Company

One Shell Plaza
P O Box 4320
Houston, Texas 77210

January 31, 1988

Office of the Program Manager for Rocky Mountain Arsenal
ATTN: AMXRM-PM: Mr. Donald L. Campbell
Rocky Mountain Arsenal, Building 111
Commerce City, Colorado 80022-2180

Dear Mr. Campbell:

For the purpose of apprising the other Organizations and DOI of progress on the Basin A Neck Groundwater Intercept and Treatment Interim Response Action, pursuant to Article 9.14 of the modified Consent Decree, enclosed herewith is a copy of the Preliminary Engineering Conceptual Design Package for this system.

Review of the Design Package and transmittal of any written comments to the undersigned by February 17, 1989 is requested. It is anticipated that a meeting will be scheduled during the week of February 20, 1989 for discussion of comments.

Preparation of the Implementation Document is on schedule for completion by September 16, 1989.

Sincerely,

R. D. Lundahl
Manager Technical
Denver Site Project

RDL:ajg

Enclosure

cc: (w/enclosure)
Office of the Program Manager
for Rocky Mountain Arsenal
ATTN: AMXRM-PM: Mr. Dave Parks
Rocky Mountain Arsenal, Building 111
Commerce City, CO 80022-2180

U.S. Department of the Interior
ATTN: Regional Environmental Officer
Mr. Richard P. Kruegar
Denver Federal Center, Building 67, Room 840
P.O. Box 25007
Denver, CO 80225-0007

Mr. Jeff Edson
Hazardous Materials and Waste
Management Division
Colorado Department of Health
4210 East 11th Avenue
Denver, CO 80020

Mr. Connally Mears
Director, Air and Waste Management Div.
U.S. Environmental Protection Agency,
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